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Emergency Delivery System Development for Disinfecting Ballast Water: Implications for Interim Treatment

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Project Partners

- **USGS – Leetown/Seattle Science Centers**
- **Minnesota LCCMR**
- **Great Lakes Fisheries Trust**
- **American Steamship Co.**
- **National Park Service**
- **NOAA**
- **Glosten & Associates**
- **National Parks of Lake Superior Foundation**

Deliverables

- Provide scientifically verified methods to dose, mix and neutralize a biocide in full or empty tanks onboard vessels that have no ballast treatment system installed. (Study uses a dye rather than an actual biocide)

- Evaluate the effectiveness of different mixing methods for full ballast tanks (the most difficult emergency treatment situation) and empty tanks.

- Produce draft adaptive management protocols and a salvors guide for delivery system mechanisms to be used for emergency treatment on grounded vessels or vessels containing high risk ballast.

- Produce a risk assessment model to assist managers in evaluating when emergency or interim treatment is required

Program Stepwise Approach Proposed Efforts

(Prior Effort) Field Verification Testing

(Prior Effort) CFD Analysis

(Proposed Effort) Scale Model Analysis and Field Testing

Mixing Method Class	Test No.	Test Description	Mixing Energy	Dye Method/ Particulars Method
Passive Mixing		**Ship's Underway Motion:**	Ship's Motion	
	1	**Variation A:** Bulk Dye Dose on Top		Bulk Load Applied at: Tank Manhole or Vent
	2	**Variation B:** Bulk Dye Dose through Sounding Tube		Bulk Load Applied at: Tank Sounding Tube
	3	**Variation C:** Bulk Dye Dose distributed in the Vertical Column		Bulk Load Applied by means of perforated tube hung vertically.
	4	**Filling Empty Tank:** Bulk Dye Dose on Bottom	Hydraulic Energy of Loaded Ballast Water	Bulk Load Applied at Tank Manhole or Tank Vent
	5	**In-Line Dye Injection into Ballast Main**	Turbulent Flow of Ballast Water in Pipe	Metering Pump Injection in Ballast Main
Active Mechanical Mixing	6	**Axial Flow Propeller**	Mechanical Device Inserted thru Tank Manhole	Metering Pump Injection behind Propeller Blade
		Venturi Mixing In Tank	Venturi Device Inserted thru Tank Manhole	
	7	**Variation A:** Dye Pumped into Eductor Line		Metering Pump Injection into Eductor
	8	**Variation B:** Dye Proportioned by Venturi Effect into Eductor Line		Venturi Effect Using a Metering Valve to Proportion Dye into Eductor
	9	**Variation C:** Dye Bulk Dosing		Bulk Load Dropped thru Tank Manholes

Ballast Treatment Chemicals.

Evaluation of Chemicals for Potential Treatment of Ballast Water," US Coast Guard Research and Development Center, October 2004.

Group A = Kills Broad Spectrum of Organisms,

Group B = Kills Narrow Spectrum of Organisms (USCG, 2004)

Table 5-1. Evaluation of Group A and Group B Biocides.

Biocide	Effective against Broad Range of Organisms?*	pH Inhibition	Adsorp-tion	Toxic byproducts	Recalci-trance	Shipboard Application Difficult	Cost Prohibitive	Safety Concerns	Regulatory Concerns
Group A Biocides									
Chlorine	Yes	Yes	Yes	Yes	Some	Yes	Somewhat	Yes	Yes
Chlorine dioxide	Yes	No	No	Yes†	Some	Somewhat	Yes	Yes	Some
Hydrogen peroxide	Yes	Yes	Un-known	Yes†	No	Somewhat	Somewhat	Yes	Some
Glutaraldehyde	Yes	Yes	No	No	No	No	Somewhat	No	No
Peraclean®	Yes	Unknown	Yes	Unknown	Unknown	No	No	Yes	Some
Cationic surfactants	Yes	Unknown	No	Unknown	Some	Unknown	Somewhat	Yes	Some
SeaKleen®	Yes	Unknown	No	No	No	No	No	No	No
Phenol	Yes	Unknown	Yes	No	No	Somewhat	Somewhat	Yes	Yes
Group B Biocides									
Copper	Yes	Some	Yes	No	Some	Somewhat	No	Yes	Yes
Bromine	No	Yes	Yes	Yes	Unknown	Yes	No	Yes	No
Iodine	No	Unknown	Un-known	Yes	Unknown	Somewhat	Somewhat	Yes	No
Sodium chlorite	No	Unknown	Un-known	Yes	Some	Somewhat	No	Yes	Yes
Chloramines	No	No	Some	Yes	Some	Somewhat	No	Yes	Unknown
Ozone	No	No	Yes	Yes†	No	Yes	Yes	Yes	Yes
Formaldehyde	No	Some	Un-known	No	No	Somewhat	Somewhat	Yes	Yes
Ethylene oxide	No	No	No	Yes†	No	Yes	Unknown	Yes	Yes
Dowicil® 75	No	No	Yes	Yes	No	Unknown	Unknown	Yes	Some

* If the biocide was found to be effective against six or more of the nine target organisms, a "yes" was entered. If it was effective against fewer than six, a "no" was entered.

† Toxic byproducts may form depending on existing environmental conditions

Can NAOH be Used to Treat Ballast Water or NOBOB Residuals?

USGS Research conducted in partnership with the Great Ships Initiative

Early Studies Demonstrating Biocidal Effects of NAOH Addition

1. Grabow, et al. (1969), Water Research, (3):943-953.

   Raising pH of sewage works effluent to 11.5 for 1 hr destroyed all gram negative bacteria and reduced the total plate count by 99%.

2. Sattar, et al., (1976), Can. J. Public Health, (67):221-226.

   Demonstrated a complete kill of a human pathogenic virus (Poliovirus type 1, Sabin) in sewage following treatment to pH 11.5 for 1 hr.

3. Grabow, et al., (1978), Appl. Environ. Microbiology (35):663-669.

   Achieved reductions in 97.1 – 100% of enteric viruses as well as coliform bacteria and coliphages when treating municipal wastewater to pH 11.1

Corrosion Rate of Iron and Steel

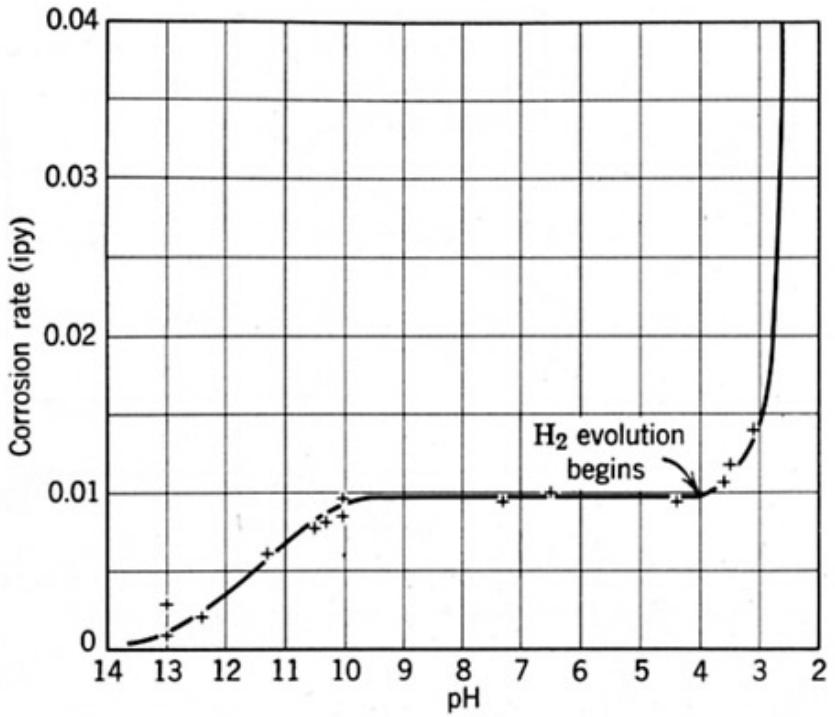

FIGURE 4. Effect of pH on corrosion of iron in aerated soft water, room temperature (Whitman, Russell, and Altieri[8]).

➢**Source: Uhlig, H.H. and R. W. Revie. 1985. Corrosion and Corrosion Control, 3rd Ed. Wiley Interscience, New York, p. 96.**

Draft Emergency Delivery System Development Document Available Upon Request